EFFECT OF LIGHT ON LEAF INCLINATION OF *TRITICUM AESTIVUM*

IV. Intermittent Irradiation and After Effect of Blue Light

Kazuyoshi KIMURA

Previous investigations showed that the inclination angle of the first leaf blade in wheat plant grown in darkness was greatly increased by continuous irradiation of blue light and that the maximum inclination occurred when the plants were exposed to 1600 erg/cm²/sec or more of blue light for 48 hours at 20-25°C (Kimura 1974, 1975).

In the present experiments, the effects of intermittent blue irradiation on blade inclination of wheat plants were investigated. Furthermore, some experiments were conducted on the effects of exposure to various colored lights before and after the promotive blue irradiation.

MATERIAL AND METHODS

The material used was the seedling of *Triticum aestivum*, "Shirasagi Komugi". Plants in plastic trays were grown on vermiculite at 20°C. The intensity of colored lights was adjusted to 2000 erg/cm²/sec at the plant level. The experimental procedures and the light sources were similar to those described in a previous paper (Kimura 1974). Generally, 30-40 plants were used for each treatment.

RESULTS AND DISCUSSION

1) Intermittent irradiation

i) Plants grown in darkness at 20°C for 9 days were exposed to various cycles consisting of equal periods of blue light and darkness (30 min, 1hr, 2hr, 4hr, 12hr, and 24hr) for 48 and 96 hours. The data on blade inclination at the end of the treatment periods are shown in Fig. 1.

The blade inclination was greatest when blue light was administered at a 24-hr light and 24-hr dark cycle, and the inclination value decreased with shortened blue-dark cycles. The relationship between cycle duration and inclination angle was similar whether the angle was measured after 48 or 96 hours of treatment, although the values after 96-hr treatment were about twice as much as those after 48-hr treatment. The final inclination angle was lower after 96-hr treatment of alternating exposure to half-hour cycles of blue light and darkness than after 48-hr of continuous irradiation, but the angle after 48-hr treatment at the same cyclic schedule was somewhat higher than that after 24-hr of continuous blue irradiation.

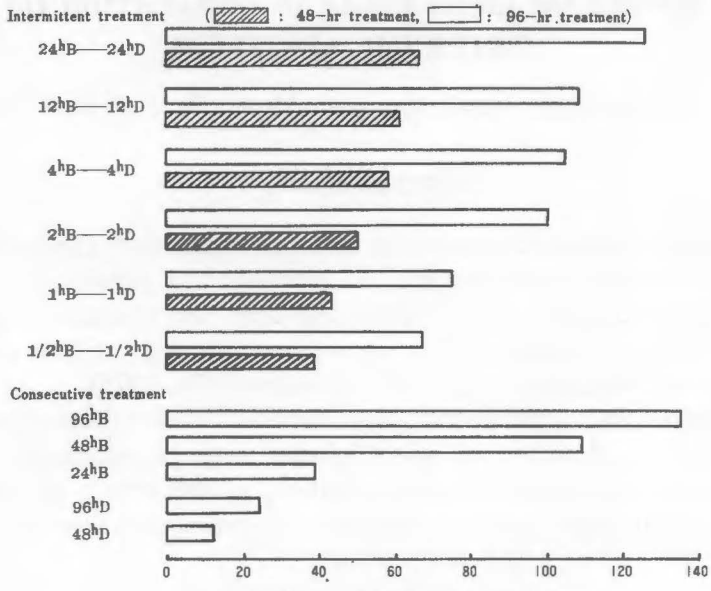

Fig. 1. Effect of intermittent blue irradiation on blade inclination of wheat plants. Plants were grown in darkness at 20°C for 9 days, and then subjected to different cycles of blue light and darkness for 48 and 96 hours. $24^{h}B$-$24^{h}D$: Alternate exposure to 24-hr blue light and 24-hr darkness. Such a notation also will be used hereafter in other cyclic treatments.

ii) Blue irradiation was applied once for 16, 24 or 32 hours, or twice for 8, 12 or 16 hours for consecutive 2 days. The experimental schedule and inclination angle obtained 48 hours after the start of the treatment are shown in Fig. 2.

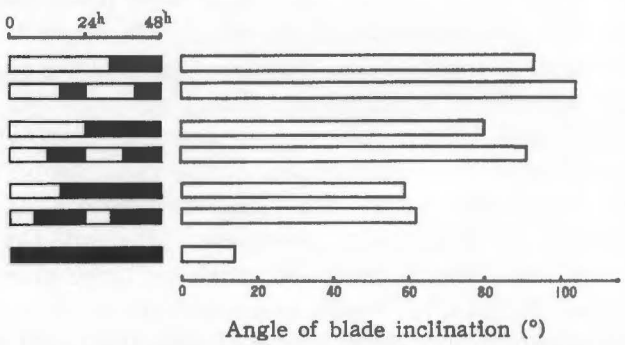

Fig. 2. Effect of intermittent irradiation of blue light on leaf blade inclination of wheat plants. Plants were grown in darkness at 20°C for 9 days, and then exposed to various blue light-dark schedules for 48 hours □: Blue light ■: Darkness

The inclination angles increased with increasing durations of blue light. However, no significant difference in blade inclination was found between plants exposed to continuous and intermittent irradiation.

2) Effect of light preceding blue light treatment

Nine-day-old dark-grown seedlings were subjected to various colored lights for 24 hours. Immediately after the treatment, they were subjected to blue light for 24 or 48 hours, and the inclination angle of the first leaves was determined at the end of treatment.

No significant differences in inclination angles were found among plants exposed to various colored lights preceding blue light treatment, except that pre-irradiation with blue light increased the response (Table 1).

TABLE 1

Inclination response of leaf blade in wheat plants subjected to various colored lights preceding blue light treatment. Plants were grown in darkness at 20°C for 8 days and then subjected to various colored lights for 24 hours. Thereafter, plants were exposed to blue light for 24 hours or 48 hours.

Pretreatment	Hours of blue irradiation after pretreatment		
	0	24	48
Blue	36.2°	85.7°	119.8°
Green	11.2°	53.4°	98.2°
Red	12.5°	52.8°	96.5°
Dark	11.6°	48.4°	97.5°

In another experiment, plants were exposed to various colored lights for 48 and 72 hours before blue light irradiation. The results were similar to those obtained in the above experiment, although the data is not presented here. These results indicate that exposure to the sampled spectral regions of light prior to inductive blue light had no effect on blade inclination.

3) Effect of light following blue light treatment

Plants were subjected to various colored lights for 24 and 48 hours immediately after 24-hr of blue light irradiation. No significant differences were found in the inclination angles of leaf blades which were exposed to various colored lights after blue irradiation (Table 2). The effect of blue light was not reduced by subsequent exposure to various colored lights, and the angles increased to some extent during the post-irradiation period. Even in darkness after blue irradiation, the inclination angles increased to the same extent as treatment with colored lights.

TABLE 2

Inclination response of leaf blade in wheat plants subjected to various colored lights after blue light treatments. Nine-day-old dark-grown plants were exposed to blue light for 24 hours, and then to various colored lights for 24 or 48 hours.
B: Blue light, G: Green light, Y: Yellow light,
R: Red light, D: Darkness,
These notations will be used hereafter.

Treatment	Leaf blade inclination (°)	Difference from value of 24^hB
24^hB	43.2	—
24^hB—24^hB	113.3	70.1
24^hB—24^hG	77.2	34.0
24^hB—24^hY	77.6	34.4
24^hB—24^hR	80.5	37.3
24^hB—24^hD	80.6	37.4
24^hB—48^hB	109.9	66.7
24^hB—48^hG	89.1	45.7
24^hB—48^hY	85.9	42.7
24^hB—48^hR	83.3	40.1
24^hB—48^hD	84.3	41.1
		Difference from value of 24^hD
24^hD	15.0	—
48^hD	22.2	6.3
72^hD	24.6	9.3

4) After effects of blue irradiation

In the preceding experiments, the inclination angles of the blade increased to some extent after the end of blue irradiation, even in darkness. To obtain more detailed information on the after-effect of blue irradiation, nine-day-old dark-grown plants were exposed to blue light for 2 to 48 hours, and then transferred to darkness for 48 hours. Observations were made immediately after blue light treatments and at the end of the subsequent dark treatment. The results are shown in Table 3.

Even after 2-8 hour of exposure to blue light, the blade inclination increased slightly in darkness. The after-effect of blue light was maximum when the plants were subjected to blue light for 24 hours.

In the next experiment, plants exposed to blue light for 24 hours were transferred to darkness, and the inclination of the leaf blade was measured at intervals of 24 hours. As the control, two lots of plants were exposed to continuous blue irradiation and total darkness.

Fig. 3 shows that the leaf blade continued to incline after the end

TABLE 3

Inclination response of wheat leaf blades subjected to darkness following various periods of blue irradiation. Plants grown in darkness at 20°C for 9 days were subjected to blue light for various hours. Thereafter, they were kept in darkness for 48 hours.

Treatment	Leaf blade inclination (°)	Difference from value immediately after blue irradiation
$2^{h}B$	0	—
$2^{h}B-48^{h}D$	13.4	13.4
$4^{h}B$	6.2	—
$4^{h}B-48^{h}D$	13.7	7.5
$8^{h}B$	10.8	—
$8^{h}B-48^{h}D$	23.8	13.1
$24^{h}B$	34.5	—
$24^{h}B-48^{h}D$	80.3	45.8
$48^{h}B$	87.6	—
$48^{h}B-48^{h}D$	114.6	27.0
$96^{h}D$	12.6	—

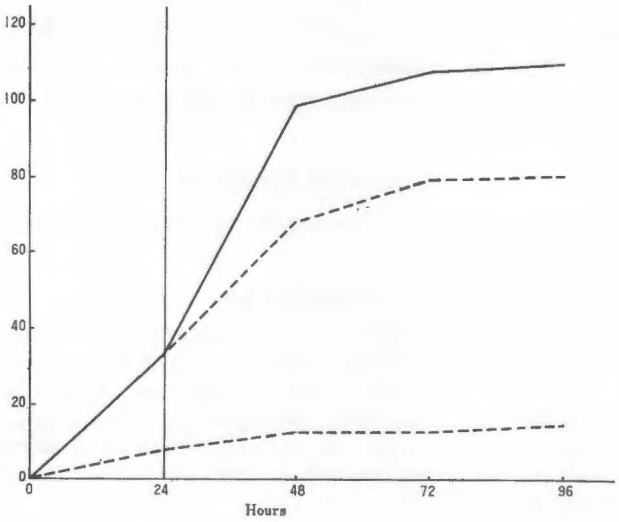

Fig. 3. Inclination response of leaf blade of wheat plants subjected to blue light and dark treatments after 24-hr of blue light treatment. Plants were grown in darkness at 20°C for 9 days and then subjected to blue light for 24 hours. After treatment, plants were exposed to blue light or darkness.
———: Blue irradiation, – – – – –: Darkness

of 24-hr blue irradiation. An increase in inclination during the first 24-hr dark period after the 24-hr blue irradiation was nearly the same as that during the initial blue irradiation, although the inclination in continuous blue light increased more rapidly during the interval from 24 to 48 hours. Maximal inclination was attained 72-96 hours after the start of blue irradiation irrespective of the presence or absence of blue light. An increase in leaf angle during the 72 hours after the end of the 24-hr blue irradiation was 78° in blue light and 48° in darkness, although plants kept in total darkness showed a leaf angle increase of only 8° during this period. The after-effect of blue irradiation is quite apparent from the results of these experiments.

SUMMARY

The effects of intermittent blue irradiation and the after-effect of blue light on leaf-blade inclination were investigated in wheat plants.

1) Alternative exposure to blue light and darkness in short cycles (30 min, 1hr, 2hr, 4hr, 12hr, or 24hr) promoted the blade inclination, although the effects decreased with shorter cycles.

2) Light at other spectral regions administered before or following effective blue irradiation had no effect on blade inclination.

3) The after-effect of blue irradiation was observed in subsequent exposures to various colored lights and darkness. The blade angle of plants subjected to blue light for 24 hours was about 35°, and the value increased to 81° during subsequent 72-hr darkness. The blade angle was only 18° in dark-grown seedlings of the same age.

ACKNOWLEDGMENT

The author wishes to express his thanks to Miss E. Kimoto for her generous assistance.

REFERENCES

1. Kimura, K. 1974. Effect of light on leaf inclination of *Triticum aestivum*. I. Monochromatic light. Ber. Ohara Inst. landw. Biol. Okayama Univ. 16: 47-56.
2. Kimura, K. 1975. Effect of light on leaf inclination of *Triticum aestivum*. II. Intensity of blue light. Ber. Ohara Inst. landw. Biol. Okayama Univ. 16: 129-133.
3. Kimura, K. 1975. Effect of light on leaf inclination of *Triticum aestivum*. III. Seedling age and photosensitive region. Ber. Ohara Inst. landw. Biol. Okayama Univ. 16: 136-146.